Sealing ability of mineral trioxide aggregate Plus™ and Biodentine™ for repair of furcal perforation in primary molars: An *in vitro* study

Farhin A. Katge, Pooja Ravindra Shivasharan, Devendra Patil

Abstract

Background: One of the unfavorable outcomes of endodontic treatment in primary molars is furcal perforation. During treatment, bacterial infection at the site of perforation should be prevented for better prognosis. **Aim:** This study aims to compare sealing ability of mineral trioxide aggregate (MTA) Plus™ and Biodentine™ for the repair of furcal perforation in primary molars using spectrophotometry. **Materials and Methods:** Access opening was done for all ninety extracted teeth. Perforation was made in furcation area in all the teeth. The sample size consisted of ninety extracted teeth. They were divided into four groups, Group 1 (n = 30) in which perforations were repaired with MTA Plus™, Group 2 (n = 30) in which perforations were repaired with Biodentine™. The other two groups were considered as control groups, Group 3 (n = 15) in which perforations were left unsealed (positive control) and Group 4 (n = 15) without perforations (negative control). Dye extraction method was used to compare the sealing ability of MTA Plus™ and Biodentine™. Statistical analysis was done using ANOVA test to compare the mean between the different groups. Intergroup comparison was performed using *post hoc* Scheffe test. **Results:** The highest dye absorbance was seen in the positive control group with a mean value of 0.080 ± 0.033. The mean value of MTA Plus™ was 0.031 ± 0.026 and Biodentine™ was 0.024 ± 0.031. **Conclusion:** The mean value of dye absorption of MTA Plus™ was greater than Biodentine™ but it was statistically insignificant.

Keywords: Biodentine, dye, mineral trioxide aggregate, perforations, primary molars

Introduction

Pulpectomy in primary teeth is considered difficult due to many reasons. These include difficulty in obtaining adequate access to the root canals in the relatively smaller mouths of children, complexity of root canal system in primary molars, the risk of injury to permanent tooth germ during cleaning, obturation of root canals, difficulties with the root canal filling materials, and methods of obturation.[1-3] Many errors and challenges are faced during access opening procedure such as the incomplete removal of caries, access opening through full-coverage restoration, inability to locate canals, failure to negotiate blocked canals, and iatrogenic perforations.[4]

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An endodontic perforation is a pathologic or iatrogenic communication between the root canal space and the attachment apparatus.[5] Biologic events such as caries, pathologic resorption, iatrogenic perforation during restorative or endodontic procedures are most often reasons causing perforation. During endodontic treatment in primary molars, furcation perforation refers to an opening into the periodontal ligament space.[5] The perforations are very often iatrogenic due to excessive use of the dental bur in the pulp chamber.[5] The repair of the root perforations must be done immediately on occurrence to reduce the possibility of infection at the perforation site.

The repair of perforation defects has been achieved using different materials. These materials include silver amalgam, calcium hydroxide, glass ionomer cement (GIC), zinc phosphate cement, resin-modified GIC, indium foil, Gutta-percha, light cure calcium hydroxide, tricalcium phosphate, dentin chips, hydroxyapatite, super ethoxy benzoic acid, light cure composite resin, and calcium-enriched mixture cement. However, none of these materials were able to re-establish

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the normal architecture predictably in perforated furcations. Therefore, there is a necessity for the introduction of newer materials for perforation repair.[6-10]

Mineral trioxide aggregate (MTA) Plus™ and Biodentine™ can be used for treating perforations in primary and permanent teeth. To compare sealing ability of MTA Plus™ and Biodentine™ for the repair of furcal perforation in primary molars using spectrophotometry.

Biodentine™ and MTA Plus™ have been used in clinical cases. Both are newer materials, and there are very few published studies regarding sealing furcation perforation in primary teeth. *In vitro* preclinical research forms a pivotal role in the development of newer dental materials and techniques. *In vitro* studies provide us with the platform to create, compare, and check dental materials before their clinical application. *In vitro* research is an integral part of clinical decision-making as this helps the clinician to understand the physical, mechanical, and biological properties of dental materials and dental hard/soft tissues. It can provide essential information for further testing of therapeutic approaches in clinical trials. Therefore, preclinical experiments should be reported with the same rigor as studies involving humans. Hence, the *in vitro* study was carried out with primary teeth.

Materials and Methods

Approval was obtained from the institutional review board of the institution for this study. The sample size was calculated based on empirical research. Ninety extracted primary molars were used in this study. The sample teeth were virgin without any prior treatment done on them. Ethical concerns related to extraction of primary molars were not known as already extracted teeth were collected from different dental institutes and private clinics, but it was assumed that they were extracted because of caries, periodontal problems, or preventive orthodontic treatments. Teeth included in the study were first and second maxillary and mandibular primary molars with intact furcation without internal or external pathologic root resorption and physiologic root resorption not more than two-third of root length. Cracked teeth and teeth with the extensive decay of crown were excluded from the study. All the teeth were kept in 5% sodium hypochlorite (Amdent, India) for 1 week for disinfection. The teeth were washed with tap water and kept in normal saline until they were used for the study.

Tooth preparation

The primary molars were amputated 3 mm apical to the furcation area using a diamond disc (SS White, Inc., Lakewood, NJ, USA). Standard coronal access was achieved in every molar with BR-46 DIA-BURS® (Mani, Japan) and EX-24 DIA-BURS® (Mani, Japan) at high speed, under cooling with distilled water. Root canal orifices were located with an endodontic explorer (API, Germany).[11] Acid etching was done at the canal orifices and the apical end of each root with 37% phosphoric acid gel (3M ESPE Dental Products, St. Paul, MN, USA) for 30 s. Adper Single Bond 2 adhesive system (3M ESPE, Dental Products, St. Paul, MN, USA) was applied in two consecutive coats and photopolymerized for 10 s with Elipar™ S10 curing light (3M ESPE, Dental Products, St. Paul, MN, USA). The canal orifices and the apical end of each root were sealed with flowable composite (3M ESPE Filtek™ Z350 XT, USA) and cured for 40 s with an S10 curing light. Two successive layers of clear nail varnish was applied to every molar including the cavity walls and pulpal floor to increase the marginal seal.[12,13]

Preparation of perforations

According to the manufacturer's instructions, silicone impression material (Speedex® putty Coltene®, Switzerland) was manipulated to provide a matrix that simulated the bony socket. All the teeth were placed into the sunset silicone impression material before polymerization. An artificial perforation was prepared in the pulp chamber of each primary tooth using RA2 bur (SS White, New Jersey) with the low-speed handpiece.[12]

The teeth were then divided into four groups, Group 1 consisting of thirty molars in which the perforations were repaired with MTA Plus™ (Prevest-Denpro, Jammu City, India) cement. Group 2 consisted of thirty molars in which the perforations were repaired with Biodentine™ (Septodont, Saint-Maur des Fosses, France) cement. The positive control was Group 3 which consisted of 15 molars in which perforations were left unsealed. Group 4 was negative control, which consisted of 15 molars without perforations.

Repair of perforations

In Group 1, the perforation site was repaired with MTA Plus™ which was manipulated according to manufacturer's instructions [Figure 1]. One scoop of powder was dispensed on a nonabsorbent pad. One small drop of the gel was dispensed from an ampoule next to the powder. It was gradually mixed with a plastic spatula provided in the kit until the desired putty-like consistency was obtained. It was then

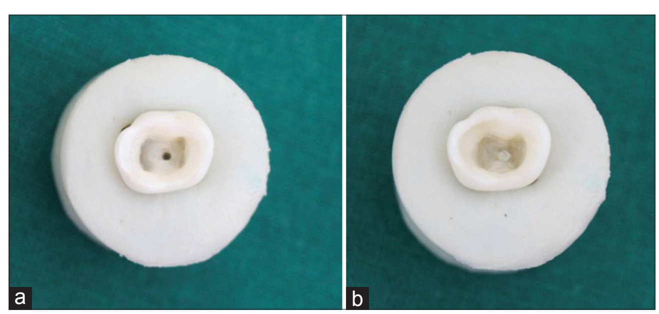


Figure 1: Perforation repair (a) creation of perforation with RA2 bur (SS White, New Jersey, USA) (b) the perforation site was repaired with mineral trioxide aggregate Plus™ (Prevest-Denpro, Jammu City, India)

carried with a plastic carrying instrument and compacted with a hand plugger at the site of perforation. A cotton pellet was moistened with saline and placed against the MTA Plus™ for 1 h until it set.[11] The perforation site was repaired with Biodentine™ in Group 2. According to the manufacturer's instructions, the capsule was gently tapped on a hard surface to loosen the powder. A single-dose container of liquid was twisted open, and five drops were poured into the capsule. The capsule was closed and placed in the CapMix™ (3M ESPE, Dental Products, St. Paul, MN, USA) for 30 s. The capsule was opened and the material was carried to the perforation site and compacted similar to MTA Plus™. After sealing of perforations, the samples were kept in 100% humidity for 24 h to allow the material to set.[11]

Dispensing of dye

One drop of 1% basic fuchsin (Magnil Dye Chem, Mumbai, India) (1 g in 100 ml distilled water) dye was dispensed into the access cavity of all primary teeth using a dropper and kept for the next 24 h. The residue of basic fuchsin dye was removed by placing the teeth under tap water for 30 min. Later, the varnish was scraped using Bard-Parker blade # 15 (API, Germany).[14]

Measurement of microleakage

The molars were placed in vials containing 2 ml of concentrated (65 weight %) nitric acid (Qualigens Fine Chemicals, Mumbai, Maharashtra, India) until complete dissolution. Centrifugations of the vials were done at 6000 rpm for 7 min to separate the debris (Centrifuge REMI R-8C, India). One ml of the supernatant from each sample was transferred to the glass cuvette. Sample absorbance was determined by UV-spectrophotometer (Shimadzu UV-160, Shimadzu Corp., Kyoto, Japan) at 545 nm using concentrated nitric acid as a blank.[15]

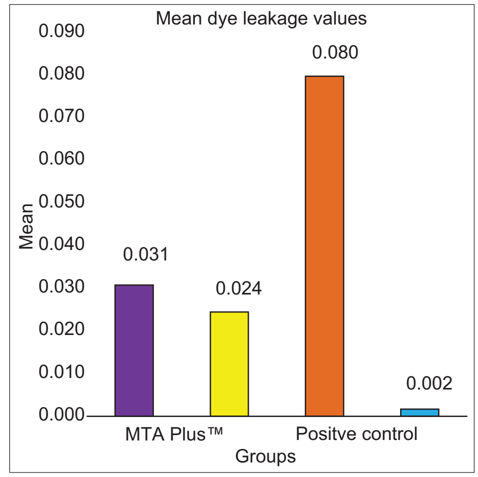
Statistical analysis

Data analysis was done using Windows PC based software "MedCalc Statistical Software" version 13.3.1 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2014). ANOVA test was used to compare the mean between the different groups. The significance level was set at $P \leq 0.05$. The intergroup comparison between the groups was performed using *post hoc* Scheffe test.

Results

The highest dye absorbance with a mean value of 0.080 ± 0.033 was seen in the positive control group. The mean value of MTA Plus™ was 0.031 ± 0.026 and Biodentine™ was 0.024 ± 0.031. The corresponding values were less than positive control but higher than the negative control [Table 1 and Graph 1].

Although the mean value of dye absorption of MTA Plus™ was greater than Biodentine™, it was statistically insignificant. There was a statistically significant difference between the mean values of MTA Plus™ when compared with positive ($P = 0.001$) and negative ($P = 0.013$) control groups. The results showed statistically significant difference when Biodentine™ was compared with positive control group ($P = 0.0001$). Whereas there was no statistically significant difference between the Biodentine™ and negative control



Graph 1: Mean optical density of dye absorbance values in four groups

Table 1: Mean optical density of dye absorbance values in four groups

	n	Mean±SD	95% CI for mean		$P^{\dagger}$
			Lower	Upper	
Group 1	30	0.031±0.026	0.021	0.041	0.001*
Group 2	30	0.024±0.031	0.013	0.036	
Group 3	15	0.080±0.033	0.062	0.098	
Group 4	15	0.002±0.001	0.001	0.002	

*Significant *P* value, †*P*≤0.05: Statistically significant. *n*: Number of samples; SD: Standard deviation; CI: Confidence interval

Table 2: Sealability between mineral trioxide aggregate plus, biodentine, and control groups

Intergroup comparisons	Mean difference	95% CI		*P*
		Lower	Upper	
Group 1 versus Group 2	0.006	−0.014	0.026	0.845
Group 1 versus Group 3	−0.049	−0.074	−0.024	0.0001*
Group 1 versus Group 4	0.029	0.005	0.054	0.013*
Group 2 versus Group 3	−0.055	−0.080	−0.031	0.0001*
Group 2 versus Group 4	0.023	−0.002	0.047	0.079
Group 3 versus Group 4	0.078	0.050	0.106	0.0001*

*Significant *P* value. CI: Confidence interval group (P = 0.079). MTA Plus™ showed no statistically significant difference in the mean value when compared with Biodentine™ group (P = 0.845) [Table 2].

Discussion

The anatomical structure of primary teeth differs from permanent teeth in the number of ways.[16] Compared to permanent teeth, primary teeth have thinner enamel, marked cervical prominence of enamel, gingival to which is marked cervical constriction and thin pulpal floor. These anatomical variations between primary and permanent teeth dictate different approaches to both cavity design and pulp therapy. These variations in the anatomy may be the reason for iatrogenic perforations in teeth during the access cavity preparation.[17]

The root perforations can be identified by diagnostic aids like indirect bleeding assessment using a paper point, radiography, direct observation of bleeding and an apex locator.[7]

Furcal perforation causes secondary inflammation of the periodontal attachment, which can lead to the loss of tooth if not treated. During treatment, bacterial infection at the site of perforation should be prevented for better prognosis.[18] The prognosis of a tooth with perforation depends on the amount of time the perforation is open to contamination, the location of the perforation, the possibility of sealing the perforation and accessibility of the main canal.[19]

The degree of tissue response to perforations treated with various materials depends on several factors such as severity of initial damage to the periodontal tissue, sealing ability, cytotoxicity of repair materials, bacterial contamination, time elapsed before the defect is repaired, size and location of perforations.[7,20]

The perforations that are immediately sealed and small perforation that occurs away from the gingival sulcus show favorable prognosis.[21]

In the management of furcal perforations, it is important to arrest the inflammatory process and loss of tissue attachment at the site of the perforation.[22]

The ideal repair material should induce osteogenesis, cementogenesis, should be biocompatible, nontoxic, noncarcinogenic, easily obtainable, convenient to use and relatively inexpensive. It should also be completely degraded during the repair process to allow for its replacement by new, healthy bone and act as a barrier against which the root canal obturating material can be placed.[23]

MTA, introduced by Torabinejad M in 1990 was used as a material of choice for all dentinal defects.[24] It consists of tricalcium and dicalcium silicate, bismuth oxide, calcium sulfate and silica.[25] MTA Plus™ was then developed by Prevest Dentpro (Jammu, India) with finer particle size which improves its handling properties and increases the speed of hydration process. MTA Plus™ kit has an optional gel as the mixing vehicle to enhance its washout resistance. The mixing liquid has a salt-free polymer gel.

Another bioactive material Biodentine™ was taken as one of the furcal perforation sealers in comparison with MTA Plus™ in our study. Biodentine™ was introduced by Gilles and Olivier in 2010.[26] It is available in powder and liquid form. The powder consists of tricalcium silicate as the main core material, dicalcium silicate as the second core material, calcium carbonate oxide which acts as a filler, iron oxide as a coloring agent and zirconium oxide which acts as a radio-opacifier. Liquid consists of calcium chloride as an accelerator and hydrosoluble polymer which acts as water reducing agent. It is a fast-setting calcium silicate based restorative material recommended for use as a dentin substitute that can be used as a coronal restoration material for perforation repair.[25,27]

Different leakage models have been used to assess the ability of materials to seal furcation perforations including fluid-infiltration, dye penetration, bacterial leakage models, dye extraction, air pressure method, an electrochemical method, radioisotope method, metal solution tracers, reverse diffusion method, three dimensional methods.[28] Camps and Pashley showed similar results with dye extraction and fluid infiltration method while saving the laboratory time with the former method.[15] Kaya *et al*. also showed that the volumetric determination of dye penetration method was same as dye extraction method but because of simplified procedure dye extraction may be preferred for further studies.[29]

Bacterial leakage studies though more reliable as compared with the dye studies, do not simulate the conditions of the oral cavity and require long periods of observation time. De-Deus *et al*.[30] evaluated the sensitivity and sealability of dye extraction and bacterial leakage techniques. They concluded that both techniques have low sensitivity to detect differences between the filling techniques and these differences might have been too small to detect.

Dye extraction method provides more reliable results than dye penetration method since it measures all the dye taken up in the root quantitatively.[11] Therefore, in the present study, microleakage was checked using dye extraction method.

The microleakage results are adversely affected by the compatibility of the dye materials and tested materials. The dyes used for assessing microleakage with dye extraction method in other studies are either methylene blue[31,32] or basic fuchsin.[33,34]

Methylene blue is incompatible with alkaline substances, which induces discoloration of the dye in marginal sealing studies. Hence, the use of methylene blue in marginal sealing studies is questionable. Duarte *et al*. have shown that calcium oxide is in MTA forms calcium hydroxide when it is mixed with water with a subsequent increase in pH.[35] This causes discoloration of the surfaces stained by methylene blue. Hence, basic fuchsin solution is preferred for evaluating the sealing ability of MTA Plus™ and Biodentine™.[31] Spectrophotometry due to its higher sensitivity, low cost, low interference level and its excellent detection capability is widely used for the determination of dye.[36,37] Thus, basic fuchsin dye has been determined spectrophotometrically in this study.

The results of the present study showed lowest dye absorbance with negative control group (0.002 ± 0.001) which was close to nitric acid (blank) with a value of 0. This difference can be attributed to the greyish-white color of the primary molars, whereas the blank is colorless. The positive control group had the highest dye absorbance (0.080 ± 0.033) value of all tested groups which shows the accuracy of the technique.[32]

The dye absorbance values of MTA Plus™ group (0.031 ± 0.026) and Biodentine™ group (0.024 ± 0.031) were not statistically significant.

When compared to MTA Plus™, Biodentine™ had almost similar physical and chemical features. The consistency of Biodentine™ was better than MTA Plus™ for clinical use. Biodentine™ had better handling properties over MTA Plus™. Setting time of Biodentine™ was less when compared to MTA Plus™ and thus there were fewer chances of bacterial contamination.[38]

Conclusion

The dye leakage of Biodentine™ was less when compared to MTA Plus™, but was not statistically significant. Therefore, the sealing capability of MTA Plus™ is comparable to Biodentine™ in furcation repair. Thus, both MTA Plus™ and Biodentine™ can be used to repair the furcal perforations in the primary molars efficiently. Long-term follow-up studies will have to be conducted to determine the use of these materials in the management of furcal perforations.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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